CRUSHED STONE JOURNAL

MARCH 1960

OFFICIAL PUBLICATION OF THE NATIONAL CRUSHED STONE ASSOCIATION

PLAN TO ATTEND

NATIONAL CRUSHED
STONE ASSOCIATION

44TH Annual Convention

AMERICANA
HOTEL

Week of

January 15, 1961

BAL HARBOUR, MIAMI BEACH, FLORIDA

Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

VOL. XXXV No. 1 PUBLISHED QUARTERLY March 1960

NATIONAL CRUSHED STONE ASSOCIATION

1415 Elliot Place, N. W.
Washington 7, D. C.

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B. G. WOOLPERT

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D. L. WILLIAMS

EDITOR

J. R. BOYD

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Cover Photograph—Glen Mills Quarry of the General Crushed Stone Company, Glen Mills, Pennsylvania

GEORGE D. LOTT, JR.
President
Palmetto Quarries Co.
Columbia, S. C.

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Elected President
NATIONAL CRUSHED STONE ASSOCIATION
by its Board of Directors
Chicago, Illinois
February 21, 1960

GEORGE D. FRAUNFELDER
Vice President—Engineering
Easton Car and Construction Co.
Easton, Pa.

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Elected Chairman
MANUFACTURERS DIVISION
by its Board of Directors
Chicago, Illinois
February 21, 1960

43rd Annual Convention and Exposition Attended by Over 2,000

THE 43rd Annual Convention and Exposition of the National Crushed Stone Association held at the Conrad Hilton, Chicago, Illinois, on February 22, 23, and 24, 1960, has been acclaimed by those in attendance as the best NCSA Convention ever held—and with good reason judging from the highly complimentary observations made during the Convention and by the many congratulatory letters subsequently received. Convention sessions, frequently filled to overflowing, further attested to the value and importance of the subjects discussed before the hundreds of crushed stone producers, manufacturers, highway officials, and guests attending this tremendously successful annual event.

The Convention Arrangements Committee under the Chairmanship of G. D. Lott, Jr., gave much time and effort to the development of an excellent Convention program which proved both practical and profitable.

The Manufacturers Division Exposition was by all standards the most attractive and comprehensive ever held. It unquestionably reflected the painstaking work of the Exposition Committee of the Manufacturers Division under the Chairmanship of W. E. Collins, Jr., and the helpfully cooperative attitude on the part of the exhibitors in the planning and preparation of the exhibits.

The record number of ladies in attendance were equally as enthusiastic over the excellent program which had been planned for their entertainment, and without question the success of the ladies activities was due in large measure to the three gracious and charming hostesses, Mrs. W. C. Rowe, Mrs. W. E. Collins, Jr., and Mrs. M. E. McLean.

George D. Lott, Jr., New NCSA President

The Board of Directors of the National Crushed Stone Association, which was elected by mail ballot prior to the Annual Convention, held its organizing meeting Sunday afternoon, February 21, 1960. At this meeting the Board of Directors elected the Officers and members of the Executive Committee who will serve for the year 1960.

G. D. Lott, Jr., President, Palmetto Quarries Co., Columbia, South Carolina, was unanimously elected President of the National Crushed Stone Association.

NCSA Variety Night, February 24, 1960, Grand Ball Room, Conrad Hilton, Chicago, Illinois

G. D. LOTT
Palmetto Quarries Co.
Columbia, S. C.
President
National Crushed Stone Association

CHARLES COBURN
Waukesha Lime & Stone Co., Inc.
Waukesha, Wis.
Vice President
National Crushed Stone Association

W. C. ROWE
Rowe Contracting Co.
Malden, Mass.
Immediate Past President

O. E. BENSON
General Crushed Stone Co.
Easton, Pa.
Elected Past President

EXECUTIVE COMMITTEE

of the

NATIONAL CRUSHED STONE ASSOCIATION

for 1960

W. P. FOSS
New York Trap Rock Corp.
West Nyack, N. Y.

D. C. HARPER
Southwest Stone Co.
Dallas, Texas

J. L. HOLDEN
Genesee Stone Products Corp.
Batavia, N. Y.

M. E. MCLEAN
East St. Louis Stone Co.
East St. Louis, Ill.

W. D. MILNE
Kentucky Stone Co.
Louisville, Ky.

D. L. WILLIAMS
Virginian Limestone Corp.
Ripplemead, Va.

G. D. FRAUNFELDER
Easton Car and Construction Co.
Easton, Pa.
Chairman
Manufacturers Division

In accepting this honor Mr. Lott expressed his deep appreciation to the Board for its confidence and pledged to do his utmost to further the aims and purposes of the Association.

To retiring President Rowe the Board enthusiastically extended a rising vote of appreciation for his unselfish and outstanding service to the Association during the past year.

Mr. Rowe thanked the members of the Board for their wholehearted cooperation during his term of office.

J. R. CALLANAN
Callanan Road
Improvement Co.
So. Bethlehem, N. Y.
Re-elected Treasurer

Other officers elected were as follows: Vice President: Charles Coburn, President, Waukesha Lime & Stone Co., Inc., Waukesha, Wis.; Treasurer: J. R. Callanan, President, Callanan Road Improvement Co., South Bethlehem, N. Y.; Secretary: J. R. Boyd, National Crushed Stone Association, Washington, D. C.

Photographs of the nine Regional Vice Presidents who were also elected by mail ballot in advance of the Annual Convention, and the area each represents, appear on page 6.

Election of Executive Committee

From among the eligible past Presidents, O. E. Benson, President, General Crushed Stone Co., Easton, Pa., was elected to serve on the Executive Committee for the year 1960. From the eligible elected members of the Board of Directors the following were unanimously elected to serve on the Executive Committee: W. P. Foss, President, New York Trap Rock Corp., West Nyack, N. Y.; D. C. Harper, President, Southwest Stone Co., Dallas, Texas; J. L. Holden, Vice President, Genesee Stone Products Corp., Batavia, N. Y.; M. E. McLean, President, East St. Louis Stone Co., East St. Louis, Ill.; W. D. Milne, President, Kentucky Stone Co., Louisville, Ky.; and D. L. Williams, President, Virginian Limestone Corp., Ripplemead, Va.

In addition to the elected members, the President, Vice President, and Immediate Past President of the Association and the Chairman of the Manufacturers Division serve as ex officio members of the Executive Committee.

The entire Executive Committee, including the elected and ex officio members, is as follows:

NCSA EXECUTIVE COMMITTEE

G. D. Lott, Jr., *Chairman*

O. E. Benson	J. L. Holden
Charles Coburn	M. E. McLean
W. P. Foss	W. D. Milne
G. D. Fraunfelder	W. C. Rowe
D. C. Harper	D. L. Williams

Election of Honorary Board Members

W. N. Carter, Joliet, Ill., H. A. Clark, Chicago, Ill., S. P. Moore, Cedar Rapids, Iowa, H. E. Rodes, Nashville, Tenn., O. M. Stull, Buchanan, Va., and Stirling Tomkins, West Nyack, N. Y., were unanimously elected Honorary Members of the Board of Directors.

NCSA Board of Directors Meeting, February 21, 1960

Regional Vice Presidents for 1960

National Crushed Stone Association

ABNEY BOXLEY
Southeastern
Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Virginia

A. N. FOLEY
New England
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

D. C. HARPER
Southwestern
Arizona, Arkansas, Louisiana, New Mexico, Oklahoma, Texas

R. G. L. HARSTONE
British Commonwealth
Dominion of Canada, United Kingdom, Australia, New Zealand, Union of South Africa

A. W. HEITMAN
Northern
Michigan, Minnesota, Montana, Nebraska North Dakota, South Dakota, Wisconsin

J. L. HOLDEN
Eastern
Delaware, Maryland, New Jersey, New York, Pennsylvania, District of Columbia

M. E. McLEAN
Midwestern
Illinois, Indiana, Iowa, Kansas, Missouri

A. W. McTHENIA
Central
Kentucky, Ohio, Tennessee, West Virginia

B. G. WOOLPERT
Western
Alaska, California, Colorado, Hawaii, Idaho, Nevada, Oregon, Utah, Washington, Wyoming

NEWLY ELECTED TO NCSA BOARD


C. A. BARINOWSKI


J. S. VANDERMADE


W. W. WEAVER

George D. Fraunfelder Elected Chairman of NCSA Manufacturers Division

The Board of Directors of the Manufacturers Division of the National Crushed Stone Association, elected by mail ballot prior to the Annual Convention, held its organizing meeting Sunday morning, February 21, 1960. At this meeting, the following Officers and members of the Executive Committee were elected who will serve for the year 1960: George D. Fraunfelder, Vice President-Engineering, Easton Car & Construction Co., Easton, Pa., was unanimously elected Chairman and C. Darrell Smith, Manager, Distributor Sales, Mining & Construction Division, Joy Manufacturing Co., Pittsburgh, Pa., was unanimously elected Vice Chairman.


Officers and Members of Manufacturers Division Executive Committee

Election of Division Executive Committee

From the eligible Past Chairmen L. A. Eiben, President, Northern Blower Co., Cleveland, Ohio, was elected to serve on the Executive Committee of the Manufacturers Division for the year 1960. From the eligible elected members of the Board of Directors the following were unanimously elected to serve on the Executive Committee: L. A. Rhodes, Manager, Machinery Division, Stedman Foundry & Machine Co., Inc., Aurora, Ind., and C. S. Weber, Advertising & Sales Promotion Manager, Thew Shovel Co., Lorain, Ohio.

In addition to the elected members of the Executive Committee, the Chairman, Vice Chairman, and Immediate Past Chairman of the Division, and the President of NCSA are ex officio members.

The entire Executive Committee, including elected and ex officio members, is as follows:

MANUFACTURERS DIVISION EXECUTIVE COMMITTEE

George D. Fraunfelder, *Chairman*

W. E. Collins, Jr.	L. A. Rhodes
L. A. Eiben	C. D. Smith
G. D. Lott, Jr.	C. S. Weber

The retiring Chairman of the Division, W. E. Collins, Jr., was presented, on behalf of the entire Manufacturers Division, with a plaque in appreciation of his service to the Manufacturers Division of the National Crushed Stone Association. The plaque is inscribed as follows:

For Distinguished Service
W. E. COLLINS, JR.
Chairman 1959
Manufacturers Division
National Crushed Stone Association

Mr. Collins expressed his sincere appreciation for the help and consideration he had received throughout his term of office from the Officers, Board, Committees, and members.

Convention Program Highlights

Most of the Convention sessions approached "standing room only" as top notch speakers held the undivided attention of the audience as they spoke on technical problems or matters of basic interest to producers and manufacturers. It is next to impossible, because of the high quality of the speakers, to select one presentation or topic over another as a Convention highlight. Unquestionably, everyone benefited from the variety of subjects which were presented affecting the conduct of their businesses and from the fresh viewpoints which were gained through the exchange of ideas with fellow producers and members of the Manufacturers Division.

George D. Fraunfelder
Easton Car & Construction Co.
Easton, Pa.
Chairman
Manufacturers Division

C. D. Smith
Joy Mfg. Co.
Pittsburgh, Pa.
Vice Chairman
Manufacturers Division

EXECUTIVE COMMITTEE

of the

MANUFACTURERS DIVISION

National Crushed Stone Association

for 1960

W. E. Collins, Jr.
Atlas Powder Co.
Wilmington, Del.
Immediate Past
Chairman

L. A. Eiben
Northern Blower Co.
Cleveland, Ohio
Elected Past
Chairman

L. A. Rhodes
Stedman Foundry &
Machine Co., Inc.
Aurora, Ind.

C. S. Weber
Thew Shovel Co.
Lorain, Ohio

G. D. Lott, Jr.
Palmetto Quarries Co.
Columbia, S. C.
President
National Crushed
Stone Association

Safety Contest Winners for 1958

Front Row, *left to right:* HAROLD CESSFORD, Weaver Construction Co.; T. W. JONES, New Haven Trap Rock Co.; BURR SHAVER, General Crushed Stone Co.; E. A. HEISE, Columbia Quarry Co.; GEORGE WHITE, New York Trap Rock Corp.; DONALD WINCHESTER, Superior Stone Co., Division of American-Marietta Co.; J. D. ROBERTS, Superior Stone Co., Division of American-Marietta Co.; J. R. LEADER, National Lime and Stone Co.; **Middle Row**, *left to right:* RAY VENCILL, Kentucky Stone Co.; JOHN W. MATTHEWS, General Crushed Stone Co.; MERL PRICE, General Crushed Stone Co.; J. P. CIVIAL, JR., General Crushed Stone Co.; J. P. COX, General Crushed Stone Co.; A. D. HAGWOOD, Superior Stone Co., Division of American-Marietta Co.; J. A. FOURNIER, Superior Stone Co., Division of American-Marietta Co.; LEON LEWIS, Catskill Mountain Stone Corp.; R. G. BUHS, Federal Materials Co.; **Top Row**, *left to right:* SHERMAN TAYLOR, Bradford Hills Quarry, Inc.; C. W. HUTTON, New Haven Trap Rock Co.; L. E. HINTZ, New Haven Trap Rock Co.; JOHN JORGENSEN, New York Trap Rock Corp.; WHIT J. WISE, Southwest Stone Co.; G. B. PHILLIPS, Standard Lime & Cement Co.; E. L. CHILDS, Stewart Sand & Material Co.; LEE R. SNYDER, Pete Lien & Sons; PAUL LINDNER, Consumers Co. Division, Vulcan Materials Co.

Operating Session

Well over 500 operating men and equipment manufacturers found the Tuesday morning Operating Session of unusual merit. Devoted entirely to subjects dealing with basic operating problems, this session, presided over by Montagu Hankin, Jr., Vice President, Houdaille Construction Materials, Inc., presented a wealth of practical information in a short space of time.

John Jorgensen, left, Superintendent, Tomkins Cove Quarry and George White, Superintendent, Clinton Point Quarry, both of New York Trap Rock Corporation are shown with the safety awards won in the 1958 NCSA Safety Contest

At no other time during the year do operating men and manufacturers of machinery and equipment have the opportunity to benefit from the exchange of knowledge and ideas as is possible at an Operating Session.

Luncheons Prove Popular Attraction

At the Greeting Luncheon on Monday the new Officers and Executive Committee of the National Crushed Stone Association were introduced. In addition, H. H. Kirwin, Chairman of the NCSA Accident Prevention Committee, presented the 33 winners of the National Crushed Stone Association Safety Contest with the new NCSA Safety Award plaques. Immediately following this presentation, Paul Jones, Director of Public Information, National Safety Council, gave an interesting and appealing talk to the 400 persons attending the Luncheon. With humorous yet pointed comments on safety, he emphasized that it is the responsibility of each person to help protect the lives of his fellow men.

Dr. Nicholas Nyaradi, the featured speaker at Wednesday's General Luncheon, was the former Minister of Finance of Hungary. In this capacity,

NEWLY ELECTED TO MANUFACTURERS BOARD

H. M. ALBERS
Kensington Steel
Div. of Poor & Co., Inc.
Chicago, Ill.

K. S. BLOCK
Nordberg Mfg. Co.
New York, N. Y.

C. R. BOLL
Cummins Engine
Co., Inc.
Columbus, Ind.

G. D. GRAYER
Bucyrus-Erie Co.
Richmond, Ind.

NOEL HAMILTON
Olin Mathieson
Chemical Corp.
East Alton, Ill.

KENNETH LINDSAY
Iowa Mfg. Co.
Cedar Rapids, Iowa

GILBERT SCHUELKE
Chain Belt Co.
Milwaukee, Wis.

H. L. WHITE
Eagle Iron Works
Des Moines, Iowa

Manufacturers Division Board of Directors Meeting February 21, 1960

L. W. Shugg, NCSA Director of Exhibits, is shown at left going over last minute details of the Exposition with W. E. Collins, Jr., retiring Chairman of the Manufacturers Division

Manufacturers Division Luncheon February 23, 1960

Dr. Nyaradi had frequent contacts with Russian leaders and members of the Politburo. As a result of personal experience and knowledge, he was able to point out the sometimes strange and incomprehensible thinking of the Russian people. His observations and pertinent comments often tugged at the hearts of the audience.

For members of the Manufacturers Division their Annual Luncheon, held on Tuesday, February 23, was one the high spots of the Convention. The newly elected Officers and members of the Executive Committee of the Division were introduced and matters of importance to the Division were presented and discussed.

This year the Session for Executives was held at a Luncheon with John F. Lane, NCSA General Counsel, presiding. Mr. Lane is of necessity in close contact with the Washington scene, and the legislative situation in the 86th Congress. This year's appraisal of the legislative outlook and his discussion of federal statutes and administrative rules and regulations affecting the crushed stone industry was of real value to the executives of crushed stone companies present.

Hostesses for Ladies Entertainment

MRS. W. C. ROWE, MRS. M. E. MCLEAN, MRS. W. E. COLLINS, JR.

Ladies Activities

Close to 200 ladies found much of interest and pleasure in their special program during the Convention period. In addition to the Morning Coffee Hour each day, the Cheerio Tea, and the Luncheon sessions of the general program, the ladies enjoyed a special Luncheon on Tuesday at Chicago's famous Kungsholm Restaurant. One of the most unusual and interesting restaurants in the country, it features the world famous miniature Grand Opera Theatre, which presented for NCSA a "command performance" of the well known Grand Opera, "I Pagliacci." The charm of the scenery and costumes of these intriguing little puppets will undoubtedly long be remembered.

From the many complimentary remarks received and overheard, it was obvious that the ladies found the 43rd Annual Convention extremely enjoyable.

NCSA Variety Night Climaxes Convention

The huge and beautifully appointed Grand Ballroom of the Conrad Hilton was the scene of the climactic NCSA Variety Night. The close to 600 guests were no more than seated when the lights dimmed and a colorful procession of miniature shrimp boats, held aloft by waiters, wound in and out among the tables. Each boat fluoresced magically as black light brought forth the beautiful hues and the waiters dispatched their ships' "cargo" to the surprised guests.

To add enjoyment to the evening and in keeping with the "Variety Night" theme, a number of unusually fine acts, arranged for NCSA through Jack Morton Productions, were presented by Archie Lane, the Master of Ceremonies. To the accompaniment of Bud Dinwiddie and his Orchestra, the Musical Waves set the pace for the evening with a fast moving routine featuring xylophones and tap dancers. The Trio Bassi followed with a spectacular juggling act and Johnnie O'Brien kept the entire room rollicking with peals of laughter to his side splitting humor. Wes Harrison, better known as Mr. Sound Effects, had the audience somewhat awed with his uncanny ability to mimic sounds with which all are familiar. The Ivy Five quintet brought the entertainment part of the evening to a close with a brilliant performance of melodies from "South Pacific." Sel-

(Continued on Page 28)

Ladies Luncheon February 23, 1960

Highways and the National Economy[1]

By Ellis L. Armstrong

Commissioner
Bureau of Public Roads
U. S. Department of Commerce
Washington, D. C.

Highways and Human Progress

THE long history of roadbuilding has produced many famous names and many famous materials. The massive stone blocks that distinguished the Roman roads were lasting symbols of a great empire. John McAdam and Thomas Telford left an imperishable impact on the civilization of their time. Down through the ages roadbuilders have been history makers, their records written in stone.

Transportation, the movement of people and goods, has always played a tremendously important part in human progress. Transportation has molded kingdoms, and roads have fostered freedom in many countries.

Today in America, highway transportation has taken the center of the stage for it affects not only commerce, agriculture, industry, and defense, but the daily lives of every man, woman, and child in this great country of ours. And now, as always, stone—crushed rock—is a basic material. To carry out the new long range highway program we are going to need aggregates in almost unbelievable quantities. In the years ahead we will require mountains of crushed stone, sand, gravel, slag, and other "road metals," just as we will require vast quantities of asphalt, tar, oil, and cement to bind these basic materials into our countrywide highway network, now some 3.5 million miles in extent.

The Federal-Aid Highway Act of 1956, and subsequent legislation, opened up what amounts to a new era for highway users and roadbuilders alike. But I think we can get a clearer view of this future and what it implies if we look back for a moment.

[1] Presented at the 43rd Annual Convention of the National Crushed Stone Association, Conrad Hilton, Chicago, Illinois, February 22-24, 1960

Highway Growth

In 1890 we had some 2 million miles of rural roads in this country, but only about 100,000 miles had all weather surfaces. Farmers living back from the railroad, battling dust or mud, began to demand better roads. They were joined by several million "wheelmen" who demanded easier going for their bicycles. Principal roadbuilding tools were the pick and shovel and the slip scraper.

Ten years later some 8,000 automobiles were scaring horses in our cities and on country roads, but few people dreamed that an era was coming to its end.

By 1916 annual motor vehicle production exceeded 1 million for the first time, and the federal government entered the roadbuilding field on a nationwide scale. Federal-aid legislation since that initial step in 1916 has authorized increasing amounts of money and has broadened the basic concept of our highway needs and how to meet them, but the generic Act fostered a cooperative state-federal approach which underlines and strengthens the federal-aid highway program even today.

Few partnerships have been more worthwhile—or more necessary. By 1921 there were about 10.5 million motor vehicles registered in this country and our total road and street mileage was just under 2.9 million—about 3 vehicles per mile. Here and there a few streets and main roads were crowded and there was even some talk about reaching a "saturation point" for cars. But we still felt that the real problem was how to provide more hard surfaced rural roads—to get the farmers out of the mud.

In 1930 our road mileage exceeded the 3 million mark, but cars, trucks, and buses totaled 26.5 million—that figures out to almost 9 motor vehicles per mile of roadway. More important, these vehicles were bigger and faster, and serious congestion was developing on many key routes near big cities and industrial areas. Traffic had begun to

choke our city streets and accidents cast a grim and darkening shadow over the whole country.

By 1941 the national figure was about 11 vehicles per mile, with every indication that this ratio would climb much higher. At the same time earlier trouble signs had multiplied. Costly, dangerous patterns of congestion were widespread and bumper-to-bumper traffic on city streets was threatening the very existence of downtown areas. The traffic toll in dead and wounded matched our casualties of World War II.

That war demonstrated the vital defense role of our main highways, and during the decade that followed it became clear that in order to equate the motor vehicle with our way of life, we needed a bold new approach: A plan that would not only assure us an interstate system of superhighways, but would also greatly increase the traffic bearing capacity of many presently overburdened routes.

Long Range Highway Program

That is the purpose of the Federal-Aid Highway Act of 1956: To provide a long range program for a 41,000 mile network of interstate highways, built to standards which will handle the types and volumes of traffic predicted for the system in 1975; and to so improve the federal-aid primary and secondary systems and their urban extensions that these essential routes will measure up to the Nation's immense capacities in other respects.

Today the federal-aid highway plant is 815,000 miles in extent, including the interstate system. That is about one-fourth of the Nation's total mileage. Yet these same traffic arteries now carry over 63 per cent of all motor vehicle traffic and in 10 years we expect the figure to reach nearly 70 per cent. These routes, rural, urban, and suburban include the "Main Streets" of America. Obviously these vital routes hold the key to our highway future.

Motor Vehicle Traffic and Gross National Product

And let me remind you that there is a direct and well established relationship between the volume of motor vehicle traffic and the gross national product—the total annual production of goods and services. They move together. In 1958, for example, we had 1.5 miles of highway travel for every dollar of GNP. Highway dollars are dynamic dollars and that is why safer, swifter, more efficient highways mean better, more prosperous, living for all Americans.

Here in this great country of ours, from 1956 to 1971, we expect highway travel to increase nearly 70 per cent, from 623 billion vehicle miles to more than a trillion.

This is the prospect that our highway program is geared to. The 1956 Act authorized nearly $25 billion of federal funds for improvements to the interstate system over a period of 13 fiscal years, 1957-69. The matching basis for these funds is 90 per cent federal, 10 per cent state.

The 1956 Act and later legislation also sharply increased the regular authorization for primary and secondary roads. Thus over the 5 years 1957-1961, this ABC federal aid alone will be $4.4 billion, to be matched on a 50-50 basis by the states. It is a reasonable assumption that these "regular" ABC authorizations will be continued at about the present level at least another 10 years.

Impact of Highway Program on Aggregate Industries

It would be hard to exaggerate the overall impact of such a huge construction program. Whether we are thinking in terms of labor and materials, engineers and machines, or the many, many kinds of development that go hand in hand with highway improvement, the long term prospect is hard to grasp.

Just for the moment let us focus on your own industry, crushed stone, and other aggregates.

According to our estimates, about 114,000 tons of aggregates—crushed stone, gravel, slag, and sand—are used for every million dollars' worth of construction in the federal-aid highway program. Of this figure, 49,000 tons are purchased by contractors, the remaining 65,000 tons being produced by the contractors themselves. The federal-aid construction program and similar state highway work in 1960 will total about $4.25 billion to be expended directly on construction operations. This means that federal-state construction this year will require the purchase of some 210 million tons of aggregates.

But this is not the whole construction picture. Local road and street construction will involve an expenditure of about $1.33 billion this year. Applying our factor for generally similar federal-aid secondary work (48,000 tons per $1 million of construction), this local road construction should call for the purchase of 65 million tons. Thus the total highway construction market for purchased aggregates this year is a respectable 275 million tons.

Availability of Aggregates

In recent years questions have arisen about the nationwide availability of aggregates for construction and the Bureau through its field offices has asked the state highway departments whether the known supply of aggregates is ample to take care of anticipated highway needs for at least the next 15 years.

Very briefly, the replies indicate that the supply is not considered adequate in Colorado, Mississippi, or Oklahoma; a few states have indicated localized shortages or partial deficiencies, such as a lack of crushed rock, gravel, or fine aggregates.

Quite naturally most of the states have kept track of their known sources of supply and also have looked for new sources of material in the vicinity of proposed new construction.

The Bureau has cooperated with several states in comprehensive surveys of existing and potential aggregate sources and similar "prospecting" is under consideration in several others.

Needless to say, none of this "prospecting" is done with the idea of competing with existing sources where supplies are adequate at reasonable costs. Rather the purpose is to assure an adequate overall supply of material for highway needs.

Distribution of Highway Construction Work

Highway construction like many other industries which are largely local, has a healthy share of small and medium size contractors among some 6,000 who are operating in this field.

Thus during the first 6 months of 1959 more than 4,000 federal-aid highway contracts were awarded, involving a total cost of around $1.4 billion. These contracts had an average cost of about $350,000 and they ranged from less than $25,000 up to about $10 million. Thirty per cent of the low bids received by the state highway departments were for amounts under $50,000. Put another way, contracts under $1 million accounted for 44 per cent of the total contract cost involved but represented 90 per cent of the total number of contracts offered to bid.

So no matter how you reckon it, the highway program provides a wide and equitable distribution of work throughout the country. It is distinctly a grass roots approach.

As a matter of fact Section 116(d) of the 1956 Act itself declares that it "is in the national interest to encourage and develop the actual and potential capacity of small business and to utilize this important segment of our economy to the fullest practical extent in construction of the federal-aid highway systems, including the interstate system . . . ."

Highway maintenance is also an important item. Nationwide the annual cost of maintaining our 3.5 million miles of roads and streets is about $2.4 billion. Certainly crushed stone and other aggregates figure importantly in this total.

Impact of New Highways on National Economy

Now let us turn once more to the impact of highways on our national economy. As I suggested earlier, we can approach this broad subject from several angles. Suppose we look first at the direct effects.

During the course of the program we will require close to 50 million tons of steel and almost 1.5 billion barrels of cement. More than 9 billion board feet of lumber and timber piling will be used.

This list could be extended to include a much wider range of products such as paints, aluminum, highway signs, and explosives.

There is a long range multi-billion dollar market ahead for the manufacturers of earth moving and other roadbuilding machinery.

These are solid, down-to-earth estimates, but they are mainly on the surface. We will have to dig much deeper to uncover the real magnitude, the full promise of the new highway program.

Let's begin with agriculture and farm life. Today more than 4.5 million cars and nearly 3 million trucks give our farm families year round access to a nationwide network of rural roads and these in turn connect with countless communities, towns, and cities, with markets and sources of supply. Beyond a doubt this transport system has contributed greatly to the steadily increasing productivity which features American agriculture from coast to coast.

These and other highway benefits are reflected in rural land values. U. S. Department of Agriculture reports indicate that farms served by gravel roads sell from 3 to 11 per cent more than similar property located on dirt roads; while for paved roads the figure goes up to 32 per cent. Other studies have indicated that the price differentials may run from 38 to 78 per cent in favor of better roads.

The multiple role of highway transport in business and industry is obvious—so obvious that some

of us may take it for granted. Express routes around big cities, like Massachusetts Route 128, which skirts Boston, have sparked the growth of industrial parks, residential areas, and shopping centers. Expressways and thruways have given much greater mobility and wider job opportunities to most of the labor force.

The famous New York Thruway has attracted some $650 million worth of industrial, commercial, and residential development along its 538 mile route—and the story is not ended. These great traffic corridors bring development in depth, by contrast to the ribbon pattern of growth that was so common when 2 lane or 4 lane pavements without access control were pushed out into the countryside.

Today there is an area close to California's East Shore Freeway which covers only 9 per cent of the total industrial acreage in Alameda County and yet has attracted well over 40 per cent of the dollars invested in new industries in that county.

Looking to the Southwest, "before and after" studies of the Gulf Freeway and the Dallas Expressway afford striking examples of the effect such highways have on adjacent land values—increases of 500 to 700 per cent were recorded.

Here in Chicago, the Edens Expressway and other magnificent traffic corridors with their skillfully planned interchanges are telling a thrilling story.

New Highways and Traffic Safety

Beyond the economic dividends that the new highway program promises, beyond the improved urban and city betterments that are implicit in sound highway planning, lies perhaps the most important factor of all—increased traffic safety.

Last year traffic accidents took close to 38,000 lives. In towns and cities, on the open road and even on dead end streets, this perpetual panorama of sudden death never ceased from coast to coast. But even that ghastly backdrop does not tell the whole traffic accident story. Last year about 1.4 million men, women, and children were injured, many were left hopelessly crippled and more than 100,000 suffered permanent physical impairment.

Moneywise, the annual drain from traffic accidents is more than $5.6 billion dollars. Some of us pay more than others but this cost is not restricted to so-called "victims" of traffic accidents—it shows up as a charge against our way of life.

When it comes to the cost of congestion and traffic delays, the estimated price tag varies. For instance the Automobile Manufacturers Association has estimated that when the interstate system is completed highway users will save $500 million a year in vehicle operating costs, plus another $825 million in time losses by commercial vehicles, and $725 million in reduced losses from accidents.

Fortunately, we now know that modern design standards, including controlled access, can drastically reduce highway accidents.

Last year on most of our toll expressways the death rate per 100 million vehicle miles of travel was about a third of the national rate on rural roads. And some of the newer facilities like the New York Thruway and the Edens Expressway are cutting the toll far below the national rate.

When it is completed we expect the interstate system to save at least 4,000 lives a year.

And let's not forget that as the regular ABC program of federal aid goes forward safety will be prominently featured in the design and construction of these vital arteries.

Current Progress of Federal-Aid Program

I imagine most of you are quite familiar with progress on some phase of the federal-aid program, because you have had a direct hand in it. Suppose I give you a quick overall run down—in terms of money, pavement, and structures.

Construction is going forward on 4,500 miles of the national system of interstate and defense highways at an estimated cost of $2.82 billion. Since July 1, 1956, construction contracts have been completed on 5,900 miles of the system at a cost of $2.42 billion. Included in the program were about 4,600 bridges under way and 4,700 completed. Moreover, an additional $2.21 billion has been authorized or spent for preliminary engineering work and right-of-way acquisition in the period since July 1, 1956.

And the continuing programs of federal aid for the primary and secondary systems and their urban extensions also set new records. Work is under way on 19,000 miles, including 4,300 bridges, at an estimated cost of $2.29 billion. Since July 1, 1956, ABC construction contracts have been completed on 95,700 miles and 15,800 bridges, at a cost of $5.75 billion. These ABC program figures include the work being accomplished with the spe-

(*Continued on Page 27*)

How Good is Good Enough[1]

By F. V. Reagel

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ALTHOUGH the subject assigned for this discussion could be considered to include all aggregates, both fine and coarse and natural and manufactured, I shall confine my remarks to the class in which this group should be most interested—crushed stone.

Even in this selection I find myself limited in experience to the manufactured products commonly used in the Middlewest, more specifically the crushed carbonate stones, limestones, and dolomites.

Basis for Specifications

My experience with, and interest in, crushed stone or aggregate specifications dates back some 40 years to the end of the first World War. From that time, even to the present, a good sound basis for specifications has been considered to be "The Best Economically Available" material.

This basis ducks the problem of trying to fit locally produced bulk materials, such as crushed stone, to national or even statewide specifications. Such specifications are based generally on characteristics of the aggregate itself instead of the quality or serviceability of the finished product manufactured from it. It also avoids the necessity for knowing "How Good Is Good Enough," which depends upon the end product and the degree or margin of safety desired.

All the specification designer needs to do is to ascertain what degree of empirical quality is available in sufficient quantities for his need and then place a specification floor under the degree of quality, plus safety factor, so obtained. He still may have only the faintest idea of the lower levels of quality which might serve, or the ultimate economy which might be achieved. We buy our suits on somewhat similar basis. For example, one man would not be caught in, say a $35 suit, but finally purchases a suit at the highest price level that he can afford—or for him "the best economically available" suit. We each give our own definition to "economical."

Relationship of End Use and Specifications

Let us consider some of the end product uses for aggregates in the highway and related fields together with some related specification items and limits.

We may be accustomed to think more of quality in connection with higher type or higher cost use, such as portland cement or bituminous concrete pavements, designed to carry heavy loads in great numbers. In such specifications we will probably find the requirements that the coarse aggregates shall be hard and durable as determined by some form of wear test and by resistance to a freezing and thawing test of some type. The constants or limits set in our specifications to be met as evidence of satisfactory hardness and durability are generally set by our old friend, "the best economically available," and we still have no idea of "how good is good enough."

Really, what we desire in the case of an aggregate for use in a heavy duty pavement material, is one that will have tensile and compressive resistance to provide strength to the layer comprising the pavement section or structure to be stressed by imposed loads. It must also have these desirable characteristics over a considerable span of time. In other words, it must not deteriorate under weathering so as to lose strength; it must not expand and contract to an injurious degree; and it must be compatible with other ingredients of concrete or other mixtures so that chemical reactions do not induce destruction.

Lack of Correlation of Test Results and Service Behavior

It is interesting to note that hardness, as an indirect indication of strength in concrete or resistance to degradation in bituminous mixtures, is measured by two methods, the results from which cannot be correlated throughout much of

[1] Presented at the 43rd Annual Convention of the National Crushed Stone Association, Conrad Hilton, Chicago, Illinois, February 22-24, 1960

the range of the test, and which do not necessarily have any relation to durability or serviceability as a coarse aggregate. For example, we have extremely soft material in the Middlewest which gives excellent results because it is extremely durable and also has low thermal characteristics. These factors tend to reduce expansion and contraction, and, consequently to lower "crackability" as compared to much harder materials available.

Likewise, returning to the factor of durability, we find evaluation based on several tests of the freezing and thawing or crystal-formation type which give ranges of results which often have little relation to serviceability as measured in the end product. In this field, the materials engineer really yearns for information as to "how good is good enough."

Effect of Grading on Durability

In specifications for aggregates, we will also find grading requirements in terms of percentages passing certain sizes of screens or sieves. At first glance these requirements may seem to have little bearing on quality except as the size and grading may affect workability and ease of compaction and densification. In two important respects, however, the grading or size affects durability.

If an aggregate contains deleterious material which tends to produce layers of intruded shale-like material, it is often concentrated in the larger particles so that a reduction in maximum size will naturally eliminate some of the undesirable planes of weakness and sources of deterioration. There is a current trend toward smaller maximum sizes for coarse aggregate down to 1, 3/4, or even 1/2 in. in size. Recent research reports are available which very clearly demonstrate the safety of this trend.

Quality Control Through Economical Selection of Aggregate Sizes

At the lower end of the gradation of coarse aggregate we meet the sand top size at about 1/4 to 3/8 in. The crushed stone size just above this point is often somewhat less in demand than the larger sizes. This results in a tendency on the part of the producer to overload the gradation with fines. Fine sizes have much greater surface area than the coarser and, in excess, reduce workability by grabbing moisture needed for workability. This difficulty is increased because these sizes are most prone to segregate and also to further reduce in size during handling.

One of the best methods of controlling quality of coarse aggregate, other than being naturally fortunate in the distribution of raw materials, is by saving the better grades or quality for heavy duty use and substituting for use in sub-bases and similar uses the lower quality often found in the same group of quarry ledges. This conservation is aided by giving proper consideration to sequence or combination of letting so that excavation of the poorer ledges for sub-surface use may assist in exposing ledges of higher quality. The result can be the difference between an economical or an impossible operation.

Research Needed on Lower Quality Material

For the low grade or relatively low grade operation just mentioned, we must cast adrift from "the best economically available" criterion, in the speaker's opinion. Our New England friends would probably "flip their lid" if offered some of the material we must use or "go without." They would also probably throw away our highest quality aggregates because "the best economically available" in their area is so far superior to ours.

We need rather desperately to know "how good is good enough," in connection with the use of our lower grade materials. This is because the lower quality of much of our material is a case of adulteration with deleterious material which is so difficult to remove that economics must be considered. Research must provide answers to such questions as:

1. Is the basic parent material satisfactory for heavy duty use if the deleterious adulteration is reduced?
2. How much reduction will suffice insofar as quality is concerned?
3. Will the operation to produce "good enough" quality be economically feasible?

Stockpile Hazards in Quality Control

There is another factor which affects the final quality of aggregate and in connection with which the engineer is fighting a "hard battle with a short sword." I refer to methods coming into use for placing into and removing aggregates from stockpile. It is becoming increasingly necessary that aggregates be stored either at the

point of manufacture or at the job site in order to insure the work progress.

At the same time, the contractor has found out how convenient crawler type equipment is for moving aggregate. The mobility of this type equipment results in contamination of the material being handled and in the rapid production of fines which can and does degrade the material beyond specification limits. Difficulties of this type are especially noted at ready-mix plants, which seem to be notoriously crowded and lacking in sufficient storage space.

It is true, and we hasten to admit it, that realization of the urgency of the needs mentioned here has been slow in arriving. The fact that the volume of aggregates now being required for base and shoulders on interstate roads is greater than the volume used in the pavement sections should jolt our complacency somewhat.

Missouri Research Program

You might be interested to know that a recent study of national highway research needs resulted in a recommendation that a five year program of research involving some $10 million would be desirable and profitable in the field of improvement of knowledge of aggregates and soils. The anticipated sources of funds for research of this nature are public, operating, and industry.

It might be well, at this point, to clear up one misapprehension which exists quite generally—committees cannot and do not do research. They can promote, outline, finance, review, criticize, and publish, but they cannot, as a committee, actually perform the research. Committees also suffer under another handicap—they produce according to some such law as Parkinson's, i.e., they produce inversely proportionally to the number on the committee. Ideal number equals one with power to act.

As a part of the work to be done in this field and as an example of one of the types of activity which might be anticipated, you might find the currently planned program of the Missouri State Highway Department of interest. I might say that this program is bogged down just now due to the shortage of research personnel.

The following two outlines present our current ideas as to the information that we should seek and the procedures which might produce at least a part of that information.

SUGGESTED CLASSIFICATIONS FOR AN INVENTORY OF SUPPLY OF COARSE AGGREGATE FOR PAVEMENT CONCRETE

A. Estimate of available supply from sources in current production; or from sources which have produced such material in the past.

1. Sources in which the basic material is presently considered to be of proven good quality and the contaminant content is of a nature, or can be kept so small, as to be relatively harmless. *Examples:* Plattin and Burlington limestones from a number of sources
2. Sources in which basic material is considered to be of acceptable quality, but contains contaminants of a type, or in sufficient quantity to cast doubt on the quality of the end product; but from which aggregate can be produced by ordinary methods so as to comply with our current specifications. *Examples:* Bethany Falls and St. Louis limestones from a number of sources
3. Sources in which material is essentially similar to "2" except that a larger content of contaminants, presently considered to be deleterious, precludes the production of acceptable aggregates by routine methods. *Examples:* Bethany Falls, Burlington, and St. Louis limestones from various sources
4. Sources in which basic stone might make suitable aggregate but which have been suspect because of indications of laboratory tests or of observations of concrete structures not subject to highway inspection during construction. Material from these sources has had little use. *Examples:* Chouteau, Jefferson City Cotton Rock, Winterset

B. Estimate of potential supply from undeveloped sources as indicated by Material Survey Records.

1. Generalized outline for attack on the problem of:
   a. Checking suitability of a coarse aggregate for use in concrete
   b. Studying the feasibility of beneficiating detrimentally contaminated aggregates

The purpose of this outline is to present in general terms the main elements of the above stated problem, without any specific effort being made to list or expand the detailed sub-elements. It will be obvious, however, that some detail was included. In most cases this was purposeful, in order to improve continuity and clarity; in other cases it probably reflects the wider scope of the authors' knowledge about some of the main items. The amount of detail presented is in no way related to the relative importance of these various items.

The authors suffer no illusion that the outline, as presented, embraces all facets of the problem for every aggregate that may be encountered and for each potential set of ambient conditions of exposure for the concrete in which the aggregate is used. It is hoped, however, that the outline is fairly complete in regard to Missouri aggregates, particularly the carbonate rocks, which are to be used in concrete subject to Missouri exposure. Failing this it may, at least, through serving as

a target for criticism, force more comprehensive consideration of the problem than is generally accorded it.

Not mentioned in the outline is a phase which enters into every item. It is the development of more objective criteria for setting the point, on the scale of measurement of each attribute, which determines acceptability. The ramifications of this phase are too complex and knowledge too meager for it to be included in the outline, but its importance and influence should be kept in mind.

In what follows, it is assumed that aggregate from a specific source, as contrasted with aggregates in general, is under consideration.

Outline For Study of Aggregate From Specific Source

1. Evidence from examination of existing concrete structures containing the subject aggregate, as to nature and degree of deterioration
   a. Those built under supervision of highway department
   b. Others
2. Classification by visual attributes
   On the basis of any, rather obvious, visual attributes such as color, microscopic texture, structure, and fracture, segregate the rock types into the categories:
   a. Basic stone, i.e., the rock type of preponderant occurrence
   b. Contaminants, i.e., rock type of types different from, and occurring in lesser proportion than the basic stone
3. Physical, chemical, and mineralogical characteristics
   For both 2a and 2b, and any sub-categories thereof, determine typical values for, and the range in:
   a. Pertinent physical characteristics
      (1) Bulk specific gravities at several degrees of saturation ranging from dry to saturated
      (2) Apparent density
      (3) Porosity as a proportion of bulk volume
      (4) Toughness and hardness
      (5) Tendency toward disintegration under
         (a) Soaking in H_2O
         (b) Vacuum saturation
         (c) Freezing and thawing
         (d) Sodium sulfate
   b. Chemical analysis, and calculated composition under an assumption of most probable compounds
   c. Petrographic properties of sub-classes of 2a and 2b where more detailed knowledge of texture, internal structure, and mineralogical composition seems desirable
   d. Some statistic which will characterize pore size distribution
4. Reclassification on basis of measurable physical, chemical, and mineralogical characteristics
   At this point the possibility of using an objective method of classification based on measured physical, chemical, or mineralogical characteristics should be checked. If possible, the classification by visual attributes should be dropped or modified
5. Effect of each rock type on quality of concrete containing it
   a. Reactivity with constituents of cement
      (1) Mortar bar tests containing sand made from each aggregate type
   b. Any detrimental effects of each rock type, such as excessive volume change, localized disintegration, etc., on mortar bars stored in water
   c. Resistance to frost action of small mortar bars as affected by different rock types
6. From a study of the results obtained with respect to previously listed items decide tentatively whether
   a. The basic stone is of sufficiently good quality to warrant attempts at beneficiation, if contaminant content is detrimental and excessive
   b. Any of the contaminants, or combinations thereof, is sufficiently detrimental that its proportion in the aggregate should be restricted
   c. There is indicated to be any method of reducing the content of detrimental contaminant—beneficiation which can be adapted to a producing plant
7. Laboratory trial of indicated methods of beneficiation
   a. Based on gravity differential
      (1) Heavy media separation
      (2) Jigging
   b. Based on particle disintegration under abrasion while wet
      (1) Log washer
      (2) Scrubber screen
   c. Dry disintegrators
8. Evaluation of improvement due to beneficiating treatment
   Details will depend on treatment used
   a. Comparison of contaminant content of the untreated aggregate against that of the concentrates and rejects from the treatment by
      (1) Visual classification
      (2) Physical and chemical characteristics
   b. Tests on concrete specimens containing untreated aggregate as compared with others containing treated aggregate—specific tests to be utilized will depend on type of basic stone and of contaminants
9. Evaluation of effectiveness of beneficiating process when adapted to plant scale production
   a. Comparison of contaminant content of untreated aggregate against that of the concentrates and rejects from the treatment
   b. Tests on concrete specimens
10. Consideration of the economics of beneficiation
   a. Estimate of the increased cost per unit of aggregate
   b. Estimate of value of benefits to be derived

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Modern Requirements and Use of Railroad Ballast[1]

By J. P. Datesman

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AS YOU no doubt know, the title of this paper is "MODERN REQUIREMENTS AND USE OF RAILROAD BALLAST," and being a railroad man engaged in maintenance work, I might add that the statement contained in the title is as controversial and many sided as politics; consequently, you can see that in the first statement I am certainly leading with my chin. To clarify any misunderstanding that may arise, it should be stated that all of the opinions expressed hereafter are my own.

Railroad Ballast—What It Is

Just what do we mean by "railroad ballast"? Quoting from the Glossary of the American Railway Engineering Association's manual, ballast is described as follows:

> "Selected material placed on the roadbed for the purpose of holding the track in line and surface"

Just what type of material would best fulfill the requirements specified in the description of ballast? This again is a controversial subject; but as far as I personally am concerned, the following description would just about cover an ideal ballast.

1. A crushed stone meeting explicitly the specifications as to gradation specified for either No. 4 or No. 5 stone ballast, as covered by the specifications for crushed material in the Manual of the American Railway Engineering Association
2. The percentage of wear of such crushed ballast not to exceed 15 per cent as tested in the Los Angeles machine
3. The soundness of prepared ballast, pertaining of course to freezing and thawing conditions, shall not exceed a weighed average loss of more than 5 to 8 per cent after 5 cycles when tested in the sodium sulphate soundness test
4. The weight per cubic foot to be in the neighborhood of 100 lb
5. The material should be thoroughly washed and free from dust
6. Cost not to exceed $1.25 per yd

The above specifications cover material that is an ideal and, to my knowledge, I do not believe a material meeting all of the specifications is available.

Stone as Ballast

I know all of you gentlemen are primarily interested in stone ballast, as far as railroads are concerned, regardless of the type. In considering this fact, I do not hesitate to make the statement that any stone ballast that meets the American Railway Engineering Association's specifications can, with the work equipment now on the market, be properly maintained in a railroad track regardless of the amount of traffic carried. In my following statements when I refer to any type of stone ballast, I still mean that it would have to come under the specifications I have just mentioned.

I know the foregoing is a broad statement; but before proceeding further with the discussion of ballast requirements, it would probably be a good idea to take a look at ballast conditions in general as they pertain to the railway industry, and for me to furnish facts to substantiate what I have just said concerning all types of stone ballast.

Forces Affecting Ballast

In the first place, is ballast subjected to a percussionary or wearing force? If the force is percussionary, does it have a tendency to break up the ballast or result in a combination of disintegration and wear? Is the basic force a wearing or grinding effect which has a tendency to grind the ballast and consequently to produce a dust which, combined with moisture and other wind-blown material, eventually results in a solid mass of impervious material?

[1] Presented at the 43rd Annual Convention of the National Crushed Stone Association, Conrad Hilton, Chicago, Illinois, February 22-24, 1960

Although many tests have been made by the Association of American Railroads and other institutions, I do not believe that anyone is qualified at the present time to definitely state the actual forces that are exerted on ballast. Considering this fact, it would appear that we can only assume that ballast is subjected to a combination of percussionary and wearing and grinding forces; consequently, the end result desired would more or less determine the class of material that should be secured in the first place as ballast.

Availability vs. Durability

As you no doubt know, there are many railroads which use many types of ballast only for the reason that they happen to be available on their lines. In some cases it is of inferior quality, and in other cases it happens to be of the best quality. The question which has arisen many times in this connection is whether or not it is more economical to use ballast available on-line, or purchase at a greater cost ballast available off-line of a quality with possibly twice the service life.

I happen to know, and I know this to be a fact, that about 30 per cent of the railroads in this country will agree that they are using an inferior grade of ballast simply because it is available on their lines. Going a little further into the subject, I think all of you will agree that there are types of stone ballast on the market that are very soft and consequently deteriorate very rapidly under a combination of percussionary and grinding forces. They are also subject to absorption of a great deal of water, which of course, as we all know, has a very detrimental effect on the life of ballast.

Back in 1944 I was given a position on our Railway with the title of "Drainage Engineer." At that time our ballast condition certainly was not of the best, as we had been using a very soft limestone from a Company owned quarry in Iowa, and also had better grades of limestone in the track that had been purchased, in various points in Illinois and Wisconsin, but all of this material had gone far too long before re-surfacing operations were carried out.

Performance Study of Various Types of Ballast

My first assignment was to make a complete study of ballast conditions between Clinton and Council Bluffs, Iowa, in company with an engineer from one of the larger corrugated pipe manufacturers. We went over this 350 miles of double track railroad practically on our hands and knees, having test holes dug through muddy ballast and in other locations where apparent chronic sink holes were prevalent. Also we had test holes dug in some cases where water pockets were evident and in other cases where there was trouble due to a large amount of sub-surface water. Many of these chronic conditions, regardless of their type, were located for us by section foremen who had direct responsibility for their maintenance.

There were some ideas prevalent at the time that muddy ballast was drainable, but I soon found out that such a procedure would be practically impossible, especially after a real soft limestone had deteriorated to the point where the ballast had become foul and in some cases, was practically as hard as concrete for an overall depth of from 2 to 2 1/2 ft. This layer of material was practically impervious to water. After going over the matter thoroughly with the drainage expert, there was no question in our minds that where actual drainage could be applied to correct sub-surface water pockets or intercept underground water before it damaged the adjacent roadbed, such a procedure should be followed; but where the trouble was nothing more than fouled ballast, then it was decided that drainage was not the answer. Where drainage was impossible, the only other procedure, of course, was a complete out-of-face surfacing operation which entailed the renewal of ties and the use of from 1,500 to 2,000 yd of ballast per mile to rehabilitate the tracks.

It was very evident from these studies that the soft limestone we were using from the Company owned quarry should be discontinued; and, consequently, we started to look for a new source of ballast. At that time, we could find no source of good material. We continued using the limestone which was of a good quality in Illinois and Wisconsin, but finally decided to start using blast furnace slag for ballast in Iowa. The first such material was placed in that state in 1947.

In 1957 we opened our own quartzite quarry in Wisconsin in the neighborhood of Baraboo; and since doing so, we have only used a small amount of limestone and other types of ballast. We also are using at the present time, and have been doing so for the past year or so, quartzite ballast that we have been securing from a commercial quarry at Spencer, South Dakota.

Maintenance by Skin Lifting

Now to get back to the question substantiating my statement concerning the use of stone ballast that meets AREA specifications. At the present time there is a great deal of machinery available which permits the re-surfacing by skin lifting, as we call it, which is a light raise of from 1 in. on up to possibly 1 1/2 in. and is carried out in a complete out-of-face operation. This procedure follows, when necessary, a complete rehabilitation project; that is, where the track has been re-tied and re-surfaced out-of-face due to a fouled ballast condition. We have found that this work can be carried out at a cost of between $400 and $500 per mile, labor cost only, for each cycle, although in some cases the cost will be a little higher, especially if entire sets of skin lifting machinery are not used.

We have been and are now doing this type of work. We have secured enough of this machinery for 12 complete skin lifting outfits. These outfits are composed of a tamping power jack with a wire attachment for raising the track to a grade, an electric vibratory tamper, a track liner with a wire attachment for lining the track, and in some cases a ballast regulator, some of which have broom attachments and some without, and in isolated cases we have purely mechanical brooms for dressing the track after the surfacing operation.

To bear out my statement that practically any kind of stone ballast, before classified, can be maintained in any kind of track for an indefinite length of time for between $400 and $500 per mile per cycle, I am going to quote you some figures based on our own production; but first I want to clarify any misunderstanding which may arise concerning the life of the type of ballast mentioned above based on its being properly maintained by the use of skin lifting outfits. It is my sincere belief that stone ballast, as before qualified, can be maintained indefinitely if skin lifted often enough *after a complete rehabilitation project*. By such a statement I mean whenever track conditions warrant such an operation, and such conditions, of course, are based on traffic. The cycle in no instance should exceed from 2 to 4 years in ordinary main line territory.

Maintenance Costs

Now I am going to burden you with some information pertaining to production which I believe is essential to bear out my previous statements pertaining to the maintenance of track with any type of ballast. During the year 1958, we had six skin lifting outfits, such as have been detailed before, in operation together with other partial outfits, which in general were composed only of an electric vibratory maintainer. We surfaced, on a light lift of from 1 to 2 in., 548 miles of track and secured a production of 1,820 track ft per day with an average of 11 men. The cost in man hours was 247 man hours per mile, based on an average on-track working time of only 5 hours and 27 minutes per day. The rough labor cost per mile based on the above production was $617, but this does not include additional ballast that would necessarily be required for these raises. Considering the 6 skin lifting outfits alone, we secured an average daily production of 2,142 track ft per day with 8 men and an average man hour cost per mile of 157, or a rough dollar cost of $393 per mile. Of course, this does not include additional ballast as mentioned before.

Our production figures for 1959 show that with the 12 complete skin lifting outfits we have surfaced out-of-face 533.5 miles of track, or an average of 2,221 track ft per day, with an average of 10 men and a man hour cost of 187, or roughly $420 per mile. In addition, with our partial skin lifting outfits composed of one 16 tool Jackson Maintainer and possibly a liner with a wire attachment, we have surfaced 205.5 miles of track with a total of 11 men, or 242 man hours per mile and a rough dollar cost of $544, which brings us to a grand total of 739 miles for skin lifting operations for the 1959 season. The production of 2,221 track ft per day, of course, is an average and is not the maximum, as in many cases under good working conditions, the same number of men with the same equipment would surface up to 4,000 track ft per day, but the average for the 12 complete outfits was as stated before, 2,221 ft. Of course, when tie renewal cycles come around, we use different types of extra gangs, together with a different outfit of available machinery. This permits the light raise maintenance and at the same time the necessary tie renewals. With a proper combination of these modern machines, and some additional ballast, very high production can be secured.

In this process, the old ties can be taken out and the new ones inserted, the ties spiked, then spaced, and the track surfaced and lined behind the operation which will put the track back in

first class condition and have it ready for another cycle of skin lifting and tie renewal when necessary.

The above procedure, of course, pertains to track that has previously been rehabilitated by a major re-surfacing and tie installation program.

Earlier Maintenance Procedures

Before the light surfacing equipment was available, tracks on which some of the softer stone ballast was placed had a tendency to foul. This was due to disintegration or wear of the ballast under traffic, and the fact that the ballast itself was not drainable due to this disintegration of the material. These conditions were augmented by windblown refuse, not only from passing trains but from fields and so forth, and the voids in the ballast became filled. About the only way such material could be properly maintained was to clean all of the ballast both on the shoulder and under the ties or only the shoulder portion, depending on conditions, by mechanical means, which were, and still are available. During this operation, of course, some of the ballast was lost due to the screening and after the operation was completed, it was necessary to distribute additional ballast to replace that lost by screening and re-surfacing the track.

The foregoing procedure was slower than the skin lifting method which I have outlined and also costs a great deal more money.

Obstructions Limit Use of Skin Lift

Of course, when we talk continual skin lifting or smoothing raises on a railroad track, vertical clearances will enter into the picture and other fixed objects which will restrict raises such as platforms, street crossings, and so forth. Consequently we cannot assume that the skin lifting procedure can be followed in all cases at all locations. In specific cases where skin lifting maintenance is restricted, there is modern machinery to lower the track by undercutting and then remove, or possibly clean, the old ballast. Another method, under restricting conditions, is to use the undertrack ballast plow, which will also remove the old ballast and hold the track to somewhat near its original height.

Good Grade Stone Ballast Economical

Some of these production figures that I have given you may seem somewhat abstract considering the fact that you are not railroad men, but I am offering this information with the thought in mind that, as I have stated before, it is possible to maintain a railroad track on any stone that comes within the category specified before by the use of present day work equipment. By this procedure the ballast will remain drainable due to frequent agitation, and a railroad track which has drainable ballast and is surfaced often enough, will have resiliency that will result in good-riding track. The end result, of course, is made possible by the use of new modern machinery, but ballast also enters into the picture and after all, the primary requisite for railroad ballast is whether or not it is physically qualified to withstand the percussionary or grinding effect that it is subjected to under present day heavy traffic, and at the same time be of the kind that can be economically maintained. I feel that there should be no question here that the better grades of rock, that is, the harder types, will prove to be more economically maintained due to the fact that they hold the track in line and surface longer between skin lifting operations; but I want to reiterate the statement that I do not hesitate in recommending all types of stone ballast, before classified, to be continually re-surfaced by the methods mentioned before.

Earlier I mentioned that there were many railroads which use certain types of inferior ballast simply because it happens to be available on their lines, and in connection with this fact, I believe that you people have a certain moral responsibility in trying to convince those who use inferior ballast that it is economically sound to purchase a better grade of stone regardless of whether it happens to be on their line or not. It seems hard to believe that modern railroad men do not realize that such is the case, and I know many who think along these lines.

Educational Information Needed

It may be possible that some of them need a little outside help or convincing that such is the case, and, of course, this matter is up to you.

I recently made an automobile trip to the West Coast and saw types of ballast on four or five major railroads that were not stone but seemed to be performing their function. Most of this material was placed in desert territory but even in such locations one cannot help but believe that

(Continued on Page 28)

Seismic Effects From Blasting[1]

By Dr. Leonard Obert

Chief, Applied Physics Laboratory
U. S. Bureau of Mines
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College Park, Maryland

Bureau of Mines Industry Research Project

THE quarrying industry, which includes producers of crushed stone and other mineral products, has always been plagued by a variety of complaints directly attributable to seismic effects from quarry blasting. Besides the quarrying industry, contractors for surface excavations such as road cuts, pipelines, and foundations, and mining and construction companies involved in underground excavation receive similar complaints. Many of these complaints are not valid. For example, some relate to cracking of plaster, whereas the cracking may have resulted from natural settlement of buildings, poor construction, or shrinkage. But valid or not, these complaints are sufficiently numerous to constitute a real problem and emphasize the need for facts in evaluating vibration problems attributed to blasting.

J. R. Thoenen and others in the Bureau of Mines recognized this problem and in 1930 began a Bureau research project which was supported by the National Crushed Stone Association and its member companies.

The principal objectives of this investigation were twofold:

1. To determine a propagation law; that is, the relationship between:
   a. The size of the explosive charge
   b. The distance from the shot to the measuring point, and
   c. The magnitude of the seismic effect (displacement, acceleration, etc.) at the point of measurement
2. To establish damage criteria; that is, the relationship between:
   a. The magnitude of the seismic effect, and
   b. The damage produced in a given type structure

The Bureau's investigation ended in 1942 with the publication of its Bulletin 442, "Seismic Effects of Quarry Blasting" by J. R. Thoenen and S. L. Windes. Since the conclusion of this project, additional investigators in the United States and abroad have studied other aspects of this problem and have contributed to the overall knowledge of the subject. (References 1-11)

Need for Additional Scientific Information

Although the knowledge of blasting vibrations has advanced considerably since 1930, many questions remain unanswered. The need for additional information is underlined by the relatively large number of inquiries received by the Bureau of Mines each year and which cannot be answered from the information in scientific literature. Several states have blasting codes and at least one additional state is planning such legislation. It is particularly important that reliable information regarding blasting vibrations be supplied the states so their codes do not become unnecessarily restrictive.

Related Research and Development of Seismic Instrumentation

Recent years have seen extensive research in several closely related fields. The military has investigated damage to structures from bombing, the seismologists have studied damage to structures from impulse loading, and the Bureau of Mines has investigated the generation and propagation of seismic waves in rock. These studies have produced a variety of information, some of which has a direct bearing on the quarry blasting problem. One of the more significant results from this research has been the development of better seismic instrumentation.

Bureau Undertakes Reinvestigation

Because additional blasting vibration information is needed, because improved instrumentation for seismic measurements is available, and because seismic information is available from other fields which could be enlarged upon and applied to the present problem, the Bureau of Mines decided in 1958 to reinvestigate blasting vibration phenomena. As in the previous Bureau investi-

[1] Presented at the 43rd Annual Convention of the National Crushed Stone Association, Conrad Hilton, Chicago, Illinois, February 22-24, 1960

gation, industry support was requested and was obtained. The new project is supported by the National Crushed Stone Association, the National Board of Fire Underwriters, the National Association of Mutual Casualty Companies, and the Association of Casualty and Surety Companies.

On May 6, 1959, a conference was held at the Eastern Experiment Station, Bureau of Mines, College Park, Maryland. It was attended by representatives from the cooperating groups as well as quarry operators, seismologists from industry and educational institutions, and the technical staff in the Bureau of Mines involved in blasting research. The conference gave these individuals and groups an opportunity to discuss their separate problems and interests so a comprehensive research program could be developed which would encompass all such areas.

Objectives of New Research Program

As a consequence, a 5 year research program was developed by the Bureau.

Its two major objectives are:

1. To Develop a Propagation Law for Ground-Borne Surface Vibrations

The principal independent variables in establishing such a law are the size of the explosive charge, and the charge-to-measurement-point distance. The dependent variable is either the displacement, particle velocity, or acceleration. In this research, the charge sizes will be varied over the range normally used in quarrying but they may include much larger shots, such as those used in large scale earth moving projects. The shot-to-measurement-point distance will be varied over a range so the measured seismic effects are well below those that would produce structural damage as well as those that would cause total structural damage. In addition, other secondary variables will be investigated, such as short-delay (millisecond) blasting over the delay range 9 to 50 milliseconds; the type of explosive, over a strength range of two or threefold; and the effects of various types and depths of overburden.

The propagation law studies will be made under closely controlled conditions at several quarries in various parts of the United States so that a wide variety of rock and soil types can be investigated. The seismic characteristics of the rock and soil, such as the density and propagation velocity, also will be determined. Limited investigations will be made of directional effects: the variation of a seismic effect with the direction from multiple hole quarry shots.

Concurrent with the ground-borne vibration measurements, air-pressure (over-pressure) measurements will be made for most shots. The information so obtained should make it possible to ascertain the magnitude of over-pressures produced at a given shot-to-measurement-point distance for most conventional quarry blasting shots. No attempt will be made to study the effects of anomalous atmospheric conditions, because these effects have been studied by other investigators. (References 12-13) In addition to these closely controlled shots, a large number of quarry production shots will be studied. Information from the production shots will be reduced statistically and then compared with that obtained during more closely controlled conditions so that the magnitude of deviations, if any, can be determined.

2. To Establish Damage Criteria for Various Types of Structures

This problem is more difficult because of the wide range of structural variables. To establish these criteria the Bureau proposes to combine the damage results obtained in this investigation with those from other sources. Such complementary information will come from studies of damage by conventional blasting, damage to structures from both air- and ground-borne vibrations produced by military type detonations, and structural damage produced by earthquakes.

In this investigation particular attention will be given to the relationship between the magnitude of the ground vibrations at the site of the structure and the magnitude of the vibrations produced in various parts of the structure. In addition, the Bureau hopes to accumulate other damage data from quarry and mine records, insurance company files, and investigations of complaints.

Research Program Schedule

The schedule for the Bureau's research program follows:

July 1959-January 1960	Completion of a mobile laboratory and other instrumentation including "shake-down" and preliminary tests
November 1959-May 1960	Comparison of commercially available seismic measuring instruments
January 1960-January 1962	Propagation law tests

January 1961-January 1963	Determination of damage criteria
January 1962-January 1964	Analysis of data and final reporting

Instrumentation for Investigation

Some of the instrumentation for this investigation was obtained before July 1959. The remainder of the equipment was purchased between July and November 1959. A mobile laboratory has been constructed. It has a 36 channel system including a direct writing oscillograph, amplifiers, gages, and accessory gear. This system will respond to acceleration frequencies over the range 5-2000 cycles per second and particle velocity frequencies over the range 10-2000 cycles per second. Displacement frequencies are obtained by electric integration of particle velocity and can be registered over the frequency range 10-2000 cycles per second. The sensitivity of the equipment is best described by example. Particle velocity recordings can be obtained in limestone for a 100 lb shot at a distance of 1,300 ft (corresponding to a particle velocity of 0.005 in. per second). Accelerations can be measured up to 200 G (200 times the acceleration of gravity).

FIGURE 1
Interior View of Mobile Laboratory Showing 36 Channel Recording Oscillograph and Companion Amplifiers

Figure 1 is a photograph of the interior of the instrument truck. Most of the gages used with the mobile laboratory have been calibrated against primary standards supplied by the U. S. Bureau of Standards.

FIGURE 2
Mobile Laboratory, Cable Truck, and Generator Unit, National Lime and Stone Co. Quarry, Bucyrus, Ohio

Equipment is powered by a trailer mounted, gasoline motor driven generator so that the laboratory is independent of outside power sources. A truck has been provided to carry about 30,000 ft of cable and power driven cable winding reels. Figure 2 shows the instrument truck, cable truck, and generating unit.

Several self-powered recording seismographs (displacement type) and accelerometers of the type normally used for monitoring quarry or other conventional blasting have been purchased or have been lent the Bureau for this investigation. These instruments were calibrated on the John Carroll University shaking table at Cleve-

FIGURE 3
Seismographs and Other Instruments Used for Measuring Ground Vibration

land, Ohio. These instruments are shown in Figure 3.

Progress to Date

Thus far the Bureau has taken measurements at three operations: Harry T. Campbell Sons' Corporation quarry, Texas, Md., the National Lime and Stone Company quarry, Bucyrus, Ohio, and the M. J. Grove Lime Company quarry, Frederick, Md. Although these were shakedown tests, the data obtained were satisfactory and no further changes in equipment are considered necessary.

As stated earlier, this investigation is a cooperative effort by the Bureau of Mines and industry and to date the response of industry to this program has been most gratifying. However, the complete success of the research will depend upon the continued cooperation of quarry operators in making test sites available and in permitting us to perform controlled experiments at these sites.

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Long overdue, a new Highway Engineering Handbook has just been released by McGraw-Hill Book Company, Inc., New York City. Over 40 years have elapsed since the last handbook for highway engineers appeared, and in that long interval there has been an amazing development in highway engineering knowledge.

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Highways and the National Economy

(*Continued from Page 15*)

cial $400 million provided by the Federal-Aid Highway Act of 1958.

This is a splendid record, one which clearly demonstrates that the highway fraternity, officials and engineers, contractors and suppliers, and the many groups and individuals that play a part in this vast undertaking, can do the job and keep it on schedule.

But I do want to remind you of another task, another obligation, that is never ending. I mean of course the day-in, day-out public understanding job in behalf of adequate standards, adequate financing to keep all phases of construction on schedule, and equally important, to maintain a balanced program fitted to the needs of a great and growing Nation. /NCSA

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43rd Annual Convention

(*Continued from Page 11*)

dom do you see members of an audience this large enjoy themselves any more than those attending the NCSA Variety Night.

It will be exceedingly difficult to top the practical and profitable yet thoroughly enjoyable experiences of the 43rd Annual Convention of the National Crushed Stone Association. /NCSA

Modern Requirements and Use of Railroad Ballast

(*Continued from Page 23*)

stone ballast would work out to everyone's advantage.

Sound Engineering Selling Pays Off

Another moral responsibility that you people have is not to try and sell inferior grades of stone for ballast purposes, even though you are saddled with such a product. There are many uses for limestone and other grades of stone other than for railroad ballast. If you happen to be unfortunate enough to have a real soft stone that does not meet AREA specifications, then I know that I, personally, would hesitate to try to sell it to somebody for ballast, for the very important reason that it probably would not stand up even with modern maintenance procedures and consequently there would be some severe repercussions which certainly would not be beneficial to the crushed stone industry.

I hope that the few thoughts that I have conveyed will be of benefit to you, and possibly even help you to convince some railroad that it is economically sound to use all types of stone that come within AREA specifications. This is a hard subject to talk about, especially if you are not talking to railroad men. Naturally, we in the railroad industry have many problems pertaining to ballast and methods of maintenance which possibly are not fully understood by you people who produce the stone for ballast. But regardless of this fact, it appears to me that each man in this industry who is engaged in producing stone for railroad ballast should make every effort to acquaint himself with the problems that the railway industry faces and he should attempt in every way possible to produce ballast that will work to the best advantage for all concerned./NCSA

How Good is Good Enough

(*Continued from Page 19*)

A parallel or similar outline is to be drawn as a guide to the study of beneficiation of aggregates for use in bituminous mixtures. It is our opinion, based on considerable experience, that higher percentages of contamination with some types of unsound particles may be tolerated in bituminous mixtures than in portland cement concrete mixtures. This is due to the fact that the nature of the relatively non-rigid type will permit the expansion and disruption of individual particles without harmful effects extending in appreciable areas around the action. In other words, the disruptive forces are cushioned. On the other hand, aggregates for bituminous mixtures must have considerable resistance to breakage under rolling, and it must resist "stuffing."

Similar consideration is due for aggregates to be used in low type bituminous construction, bases, and sub-bases. Our lack of research personnel is also in a large measure responsible for delay in completing and carrying forward work in this research area.

Producers Must Share Responsibility for Research Work

In closing, I might suggest that you ask yourselves whether or not you, as producers, are bearing your share of the costs and work of producing the information upon which the future of your industry will depend.

You may be assured that major changes are coming and some producers will be on the plus side and some will, unhappily, be on the negative.

Are you using enough engineering help in your management and production problems. You hardly have a valid objection to specification trends if you do not. The future size and density of highway loadings are estimated to be enormously greater than those with which we are currently familiar and they will not be "bottled up."

Above all, resist the start of substitution of political pressure for engineering judgment. Let the engineers fit the type of improvement to the environmental conditions, including traffic, and to the materials available—and you join in the effort to see that your material is "Good Enough" and ready to use. /NCSA

Highway Trust Fund Starts to Repay Advance From General Fund

THE Highway Trust Fund in February 1960, repaid $64 million of the $359 million previously advanced from the general fund. According to figures from the U. S. Treasury Department, payment of interest on these borrowed funds was also made in the amount of $377,845. The total remaining to be repaid is $295 million, consisting of $145 million borrowed in October at 3.125 per cent interest, and $150 million borrowed in November at 3.250 per cent.

Meanwhile, Treasury Secretary Anderson has sent to Congress the report for the fiscal year 1959 on the "Financial Condition and Fiscal Operations of the Highway Trust Fund."

In connection with the financing problems facing the Highway Trust Fund, the Report states: "While the Highway Act calls for construction of a 40,000 mile interstate system, the annual dollar volume authorizations approved by Congress, in the aggregate of $25,440 million will not provide for completion of the program. The Department of Commerce is now working on two basic reports for Congress covering (1) a revised estimate of cost of completing the interstate system, and (2) a study of the beneficiaries of the highway systems. These reports . . . will afford Congress an opportunity to consider what continuing taxes should be imposed, the equitable distribution of such taxes for highway purposes, and to provide for appropriate financing and scheduling of apportionments required to complete the interstate system."

The Report shows that for the first three years of operation, July 1, 1956, through June 30, 1959, the receipts of the Trust Fund were preponderantly from the gasoline tax. In percentages, the tax sources produce revenues as follows: Gasoline, 80.6; diesel fuel, 2.3; tires, 10.0; tubes, 0.5; tread rubber, 0.7; trucks, buses, trailers, 4.3; and vehicle use tax, 1.6.

The results of operations of the Trust Fund for February 1960 and for the period July 1, 1956, through February 29, 1960, are as follows:

	February 1960	July 1, 1956-February 29, 1960
RECEIPTS		
Tax Sources	$264,253,050	$7,528,954,999
Advances from General Fund	—	359,000,000
Interest on Investments	54,188	35,361,595
TOTAL	$264,307,238	$7,923,316,594
EXPENDITURES		
Federal Highways	$122,758,287	$7,360,092,896
Repayment of Advances	64,000,000	64,000,000
Interest Payment on Advances	377,845	377,845
Refunds of Taxes	27,101,699	284,729,095
Payments to Labor Department	—	368,225
TOTAL	$214,237,831	$7,709,568,061

As of February 29, 1960, the Highway Trust Fund owed the general fund $295 million and had $213.75 million on hand.

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National Crushed Stone Association

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These associate members are morally and financially aiding the Association in its efforts to protect and advance the interests of the crushed stone industry. Please give them favorable consideration whenever possible.

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Harnischfeger Corp.
4400 West National Ave., Milwaukee 46, Wis.
Complete Line of Power Cranes, Shovels, Draglines, Overhead Cranes, Hoists, Welders, Electrodes, Generators, Diesel Engines

HarriSteel Products Co.
420 Lexington Ave., New York 17, N. Y.
Woven Wire Screen Cloth

Heidenreich, E. Lee, Jr.
Consulting Engineers
75 Second St., Newburgh, N. Y.
Plant Layout, Design, Supervision; Open Pit Quarry Surveys; Appraisals—Plant and Property

Hendrick Mfg. Co.
Carbondale, Pa.
Perforated Metal Screens, Perforated Plates for Vibrating, Shaking, and Revolving Screens; Elevator Buckets; Test Screens; Wedge Slot Screens; Wedge Wire Screens; Open Steel Floor Grating

Hercules Powder Co.
Wilmington 99, Del.
Explosives and Blasting Supplies

Hetherington & Berner, Inc.
701-745 Kentucky Ave., Indianapolis 7, Ind.
Asphalt Paving Machinery, Sand and Stone Dryers

Hewitt-Robins Incorporated
666 Glenbrook Road, Stamford, Conn.
Belt Conveyors (Belting and Machinery); Belt and Bucket Elevators; Car Shakeouts; Feeders; Industrial Hose; Screen Cloth; Sectional Conveyors; Skip Hoists; Stackers; Transmission Belting; Vibrating Conveyors, Feeders, and Screens; Design and Construction of Complete Plants; Molded Rubber Goods; Sheet Packing; Transmission Belting; Dewaterizers; Wire Conveyor Belts; Speed Reducers; Gears; Pulleys; Sheaves; Couplings

Hoyt Wire Cloth Co.
P. O. Box 1577, Lancaster, Pa.
Aggregate Wire Screens Made of Supertough, Abraso, and Stainless Steel Wire—Smooth-top, Longslot, Oblong Space, and Double Crimp Construction—For All Makes of Vibrators; Rubber Bucker Up Channel

Hughes Tool Co.
P. O. Box 2539, Houston 1, Texas
Bits—Rotary Rock

Ingersoll-Rand Co.
11 Broadway, New York 4, N. Y.
Rock Drills, Paving Breakers, Paving Breaker Accessories, Quarrymaster Drills, Drill-masters, Waterwell Drills, Down-Hole Drills, Crawl-ir Drills and Wagon Drills, Carset Bits, Jackbits, Bit Reconditioning Equipment, Portable and Stationary Air Compressors, Air Hoists, Slusher Hoists, Pneumatic Tools, Centrifugal Pumps, Diesel and Gas Engines, Blowers and Fans

International Harvester Co.
Construction Equipment Division
P. O. Box 270, Melrose Park, Ill.
Crawler Tractors and Equipment, Rubber Tired Scrapers and Bottom Dump Wagons, Off-Highway Dump Trucks, Carbureted and Diesel Power Units

Iowa Manufacturing Co.
916 16th St., N. E., Cedar Rapids, Iowa
Rock and Gravel Crushing, Screening, Conveying and Washing Plants, Asphalt Plants, Stabilizer Plants, Impact Breakers, Screens, Elevators, Conveyors, Portable and Stationary Equipment, Hammermills, Bins

Jaeger Machine Co.
550 West Spring St., Columbus 16, Ohio
Portable and Stationary Air Compressors, Self-Priming Pumps, Truck Mixers, Concrete Mixers, Road Paving Machinery, Hoists and Towers; Finishers—Concrete; Spreaders—Stone and Concrete; Truck Mixers—Concrete

Manufacturers Division – National Crushed Stone Association
(continued)

Jeffrey Manufacturing Co.

815 North Fourth St., Columbus 16, Ohio

Elevator Buckets; Car Pullers; Chains; Conveyors: Belt, Drag, Apron, Vibrating; Idlers; Crushers; Pulverizers; Elevators; Feeders; Pillow Blocks; Grizzlies; Screens

Joy Manufacturing Co.

333 Henry W. Oliver Bldg., Pittsburgh 22, Pa.

Drills: Blast-Hole, Wagon, Rock, and Core; Air Compressors: Portable, Stationary, Semi-Portable; Aftercoolers; Portable Blowers; Carpullers; Hoists: Multi-Purpose, Portable; Rock Loaders; Air Motors; Trench Diggers; Belt Conveyors; "Spaders;" "String-a-Lite" (Safety Lighting Cable); Backfill Tampers; Drill Bits: Rock Core; Joy Microdyne Dust Collectors

Kennedy Van Saun Mfg. & Eng. Corp.

405 Park Ave., New York 22, N. Y.

Crushing, Screening, Washing, Conveying, Elevating, Grinding, Complete Cement Plants, Complete Lime Plants, Complete Lightweight Aggregate Plants, Synchronous Motors, Air Activated Containers for Transportation of Pulverized Material, Cement Pumps, and Power Plant Equipment

Kensington Steel
Division of Poor & Co., Inc.

505 East Kensington Ave., Chicago 28, Ill.

Oro Alloy and Manganese Steel Castings; For Shovels—Dipper Teeth, Crawler Treads, Rollers, Sprockets; For Crushers—Jaw Plates, Concaves, Concave Rings, Mantles; For Pulverizers—Hammers, Grate Bars, Liners; For Elevators and Conveyors—Chain, Sprockets, Buckets; For Tractors—Sprocket Rims, Grouser Plates; Drag Line Chain

Koehring Division
Koehring Co.

3026 West Concordia Ave., Milwaukee 16, Wis.

Excavating, Hauling, and Concrete Equipment

LeTourneau-Westinghouse Co.

2301 North Adams St., Peoria, Ill.

Earthmoving Equipment, Motor Graders, Off-Highway Trucks, Wire Rope

Link-Belt Co.

300 West Pershing Road, Chicago 9, Ill.

Complete Stone Preparation Plants; Conveyors, Elevators, Screens, Washing Equipment, and Power Transmission Equipment

Link-Belt Speeder Corp.

1201 Sixth St., S. W., Cedar Rapids, Iowa

Complete Line of Speed-o-Matic Power Hydraulically Controlled Cranes, Shovels; Hoes, Draglines, and Clamshells, 1/2 to 3-Yd Capacities; Available on Crawler Base or Rubber Tire Mounting; Diesel Pile Hammers

Lippmann Engineering Works, Inc.

4603 West Mitchell St., Milwaukee 14, Wis.

Primary and Secondary Rock Crushers and Auxiliary Equipment such as Feeders, Screens, Conveyors, etc., Portable and Stationary Crushing and Washing Plants

Ludlow-Saylor Wire Cloth Co.

634 South Newstead Ave., St. Louis 10, Mo.

Woven Wire Screens of Ludloy (Oil Tempered); Super-Loy (Hi-Carbon); Steel; Stainless Steel; All Other Commercial Alloys

Mack Trucks, Inc.

1355 West Front St., Plainfield, N. J.

4- and 6-Wheeled Trucks and Tractors—Gasoline- and Diesel-Powered from 5 to 12 Cu Yd Capacity with a Wide Choice of Transmissions and Front and Rear Axles with 2-, 4-, and 6-Wheel Drives; 4- and 6-Wheeled Off-Highway Vehicles from 15- to 40-Ton Capacity with Diesel Power Plants Available from 170 to 400 Hp

Manganese Steel Forge Co.

Richmond St. and Castor Ave., Philadelphia 34, Pa.

Rol-Man 11.00 to 14.00 Per Cent Rolled Manganese Steel Woven and Perforated Screens, and Fabricated Parts for Aggregate Handling Equipment

Marion Power Shovel Co.
Division of Universal Marion Corp.

617 West Center St., Marion, Ohio

Power Shovels, Draglines, Cranes, Truck Cranes—From 3/4 to 75 Yd

Marsh, E. F., Engineering Co.

4324 West Clayton Ave., St. Louis 10, Mo.

Belt Conveyors

Mayhew Supply Co., Inc.

4700 Scyene Road, Dallas 17, Texas

Blast Hole Drill Rigs

Manufacturers Division – National Crushed Stone Association
(continued)

McLanahan & Stone Corp.
252 Wall St., Hollidaysburg, Pa.
Complete Pit, Mine, and Quarry Equipment—Crushers, Washers, Screens, Feeders, etc., Semi-Portable Plants

Meissner Engineers, Inc.
300 West Washington St., Chicago 6, Ill.
Engineers—Constructors—Specialists in Plant Layout, Construction-Engineering Design, Procurement, Construction Management, Quarry Surveys, Plant and Property Appraisals

Murphy Diesel Co.
5317 West Burnham St., Milwaukee 19, Wis.
Engines—Industrial Engine, and Power Units for Operation on Diesel and Dual Fuel Engines. Generator Sets, AC and DC from 64 to 165 kw. Mech-Elec Unit—Combination Mechanical and Electric Power Furnished Simultaneously

New Jersey Drilling Co., Inc.
Box 251, Route 206, Netcong, N. J.
Contract Drilling; Quarry Blast Holes

New York Rubber Corp.
100 Park Ave., New York 17, N. Y.
Conveyor Belting: Stonore, Dependable, and Cameo Grades; Transmission Belting: Silver Duck Duroflex, Soft Duck Rugged, Commercial Grade Tractor

Nordberg Mfg. Co.
3073 South Chase Ave., Milwaukee 1, Wis.
Symons Cone Crushers, and Symons Gyratory and Impact Crushers; Gyradisc Crushers; Grinding Mills; Stone Plant and Cement Mill Machinery; Vibrating Screens and Grizzlies; Diesel Engines and Diesel Generator Units; Mine Hoists; Railway Track Maintenance Machinery

Northern Blower Co.
6409 Barberton Ave., Cleveland 2, Ohio
Dust Collecting Systems, Fans—Exhaust and Blower

Northwest Engineering Co.
135 South LaSalle St., Chicago 3, Ill.
Shovels, Cranes, Draglines, Pullshovels—Crawler and Truck Mounted

Olin Mathieson Chemical Corp.
Energy Division
East Alton, Ill.
Explosives, Blasting Caps, Blasting Accessories

Pennsylvania Crusher Division
Bath Iron Works Corp.
323 South Matlack St., West Chester, Pa.
Single Roll Crushers, Impactors, Reversible Hammermills, Ring Type Granulators, Kue-Ken Jaw Crushers, Kue-Ken Gyratories, Non-Clog and Standard One-Way Hammermills

Pettibone Mulliken Corp.
4710 West Division St., Chicago 51, Ill.
Tractor Shovels, Front End Loaders, Swing Loaders, Yard Cranes, Bucket and Fork Loaders, Motor Graders, Manganese Steel Castings, Material Handling Buckets, Clamshells, Draglines, Pull Shovel Dippers, Shovel Dippers, and Pumps

Pioneer Engineering
Division of Poor & Co., Inc.
3200 Como Ave., Minneapolis 14, Minn.
Jaw Crushers, Roll Crushers (Twin and Triple), Impact Crushers, Hammer-Mills, Vibrating and Revolving Screens, Feeders (Reciprocating, Apron, and Pioneer Oro Manganese Steel), Belt Conveyors, Idlers, Accessories and Trucks, Portable and Stationary Crushing and Screening Plants, Washing Plants, Mining Equipment, Cement and Lime Equipment, Asphalt Plants, Mixers, Dryers, and Pavers

Pit and Quarry Publications, Inc.
431 South Dearborn St., Chicago 5, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Modern Concrete, Concrete Industries Yearbook, Equipment Distributor's Digest

Productive Equipment Corp.
2926 West Lake St., Chicago 12, Ill.
Vibrating Screens

REICHdrill Division
Chicago Pneumatic Tool Co.
6 East 44th St., New York 17, N. Y.
Air Compressors, Rock Drills, Diesel Engines, Pneumatic Tools, Rotary and "Down-the-Hole" Drilling Machines for Exploration, Coring, Blast Holes

Rock Products
79 West Monroe St., Chicago 3, Ill.
Publications: Rock Products and Concrete Products

Manufacturers Division – National Crushed Stone Association

(continued)

Rogers Iron Works Co.

11th and Pearl Sts., Joplin, Mo.

Jaw Crushers, Roll Crushers, Hammermills, Vibrating Screens, Revolving Screens and Scrubbers, Apron Feeders, Reciprocating Feeders, Roll Grizzlys, Conveyors, Elevators, Portable and Stationary Crushing and Screening Plants, Mine Hoists, Drill Jumbos, Underground Loaders, Iron Castings, Screw Washers, and Classifying Tanks

Schramm, Inc.

West Chester, Pa.

Air Compressors: Portable and Stationary, Gasoline, Diesel, and Electric Driven; Boosters; Pneumatractors, Self-Propelled; Accessories; Bits—Rock; Rotatool Bits, Carbide Insert; Drills, Drilling Equipment; Rotadrills Mounted on Pneumatractors, Trucks and Crawlers; Ready-to-Mount Rotadrills for Mounting on Used Trucks and Crawler Tractors; Rotatools for Bottom-Hole Drilling; Rock Drills; Wagon Drills; Breakers; Accessories

Screen Equipment Co., Inc.

40 Anderson Road, Buffalo 25, N. Y.

Seco Vibrating Screens; Scales—Industrial, Aggregates, Truck

Simplicity Engineering Co.

Durand, Mich.

Simplicity Gyrating Screens, Horizontal Screens, Simpli-Flo Screens, Tray Type Screens, Heavy Duty Scalpers, D'Watering Wheels, D'Centegrators, Vibrating Feeders, Vibrating Pan Conveyors, Car Shake-Outs, Woven Wire Screen Cloth, Grizzly Feeders

Smith Engineering Works

532 East Capitol Drive, Milwaukee 12, Wis.

Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Stardrill-Keystone
Buffalo Springfield Co.
Division of Koehring Co.

1100 Kenton St., Springfield, Ohio

Drilling Machines: Rotary Air Drills, Churn Drills, Rotary Tools, Rotary Bits, Down-the-Hole Guns, Insert Type Bits, and Water Well Drills

Stedman Foundry & Machine Co., Inc.

P. O. Box 209, Aurora, Ind.

Stedman Impact-Type Selective Reduction Crushers, 2-Stage Swing Hammer Limestone Pulverizers, Multi-Cage Limestone Pulverizers, Vibrating Screens

Stephens-Adamson Mfg. Co.

Ridgeway Ave., Aurora, Ill.

Belt Conveyors, Pan Conveyors, Bucket Elevators, "Amsco" Manganese Steel Pan Feeders, Vibrating Screens, Belt Conveyor Carriers, Bin Gates, Car Pullers, "Sealmaster" Ball Bearing Units, "Saco" Speed Reducers, and Complete Engineered Stone Handling Plants

Taylor-Wharton Co.
Division Harsco Corp.

High Bridge, N. J.

Manganese and Other Special Alloy Steel and Iron Castings; Dipper Teeth, Fronts and Lips; Crawler Treads; Jaw and Cheek Plates; Mantles and Concaves; Pulverizer Hammers and Liners; Asphalt Mixer Liners and Tips; Manganese Nickel Steel Welding Rod and Plate; Elevator, Conveyor, and Dredge Buckets; Pan Feeders

Thew Shovel Co.

East 28th St. and Fulton Road, Lorain, Ohio

"Lorain" Power Shovels, Cranes, Draglines, Clamshells, Hoes on Crawlers and Rubber Tire Mountings: Diesel, Electric, and Gasoline, 3/8 to 2 1/2 Yd Capacities; "Lorain" Motor-Loader—Rubber Tire Front End Loader 1 3/4 and 2 Yd Capacity

Thor Power Tool Co.

175 North State St., Aurora, Ill.

Crawler and Hand-Held Rock Drills, Sump and Sludge Pumps, Clay Diggers, Paving Breakers, Quarry Bars, Sinker Legs, Drifters, Rock Drilling Jumbos, Raiser Legs, Push Feed Rock Drills, Air and Electric Tools, Accessories, Generator Sets, Concrete Vibrators, Power Trowels, Vibratory Screeds

Torrington Co.
Bantam Bearings Division

3702 West Sample St., South Bend 21, Ind.

Anti-Friction Bearings; Self-Aligning Spherical, Tapered, Cylindrical, and Needle Roller; Roller Thrust; Ball Bearings

Tractomotive Corp.

County Line Road, Deerfield, Ill.

Rubber Tired Front End Loaders (Tracto-Loaders)

Manufacturers Division – National Crushed Stone Association
(continued)

Traylor Eng. & Mfg.
Division of Fuller Co.

Allentown, Pa.

Stone Crushing, Gravel, Lime, and Cement Machinery

Trojan Powder Co.

17 North Seventh St., Allentown, Pa.

Explosives and Blasting Supplies

Tyler, W. S., Co.

3615 Superior Ave., N. E., Cleveland 14, Ohio

Woven Wire Screens; Ty-Rock, Tyler-Niagara and Ty-Rocket (Mechanically Vibrated) Screens; Hum-mer Electric Screens; Ro-Tap Testing Sieve Shakers, Tyler Standard Screen Scale Sieves, U. S. Sieve Series

Universal Engineering Corp.
Subsidiary of Pettibone Mulliken Corp.

625 C Ave., N. W., Cedar Rapids, Iowa

Crushers—Jaw, Roll, TwinDual Roll; Hammermills, Impact Breakers, Pulverizers, Bins, Conveyors, Feeders, Screens, Scrubbers. Bulldog Non-Clog Moving Breaker Plate and Stationary Breaker Plate Hammermills, Center Feed Hammermills. Complete Line of Stationary and Portable Crushing, Screening, Washing, and Loading Equipment for Rock, Gravel, Sand, Ore; Aglime Plants; Asphalt Plants

Varel Manufacturing Co.

9230 Denton Drive, Dallas 20, Texas

Rock Bits, Drilling; Bits: Diamond, Blade, Drag

Vibration Engineering Co.

407 Hazleton National Bank Bldg., Hazleton, Pa.

Consultants on Vibration and Blast Effects; Seismograph Sales, Rental and Record Interpretation; Pre-Blast and Post-Blast Property Inspections; Seismic and Resistivity Rock Depth Surveys; Rock Velocity Measurements

Vibration Measurement Engineers, Inc.

725 Oakton St., Evanston, Ill.

Seismographic and Airblast Measurements, Seismological Engineering, Blasting Complaint Investigations, Expert Testimony in Blasting Litigation; Complete Seismograph Rental and Record Analysis Service with "Seismolog"

Webb, Jervis B., Co.

8951 Alpine Ave., Detroit 4, Mich.

Design and Construction of Complete Material Handling Systems; Conveyors—Belt and Flight; Bucket Elevators; Feeders; Forged Chain

Werco Steel Co.

2151 East 83rd St., Chicago 17, Ill.

Castings—Manganese, Alloy Steel; Screen Plates—Perforated Steel Screen Sections and Decks; Buckets; Chains; Belt Conveyors, Idlers; Dipper—Shovel; Drop Balls; Wire Cloth; Wire Rope and Related Products; Crushers, Pulverizers

Western-Knapp Engineering Co.

50 Church St., New York 7, N. Y.

Plant Design and Construction Operating Studies; Appraisals

White Motor Co.

842 East 79th St., Cleveland 1, Ohio

On- and Off-Highway Trucks and Tractors—Gasoline- and Diesel-Powered; Industrial Engines—Gasoline and Diesel; Power Units, Axles, Special Machine Assemblies; Power Generating and Distributing Systems; Batteries; All Classes of Maintenance and Repair Service

White Motor Co.
Autocar Division

Exton, Pa.

Custom Engineered, Precision Built Trucks and Tractors for On- or Off-Highway: Gasoline or Diesel Powered, 2 or 3 Axles, Single Axle to All Axle Drives; Planetary Gear Driven Vehicles for Quarry, Mine, and Construction Operations

Wickwire Spencer Steel Division
Colorado Fuel and Iron Corp.

575 Madison Ave., New York 22, N. Y.

Wire Cloth, Screens, Screen Sections, Wire Rope—Slings

Williams Patent Crusher & Pulverizer Co.

2701-2723 North Broadway, St. Louis 6, Mo.

Hammer Mills, Crushers, Pulverizers, Roller Mills, Reversible Impactors, Vibrating Screens, Air Separators, Bins, Feeders

Wiss & Associates

570 Northwest Highway, Des Plaines, Ill.

Seismological Engineers

NATIONAL CRUSHED STONE ASSOCIATION

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